N(1081

(12) UK Patent Application (19) GB (11) 2 265 519 (13) A

(43) Date of A publication 29.09.1993

(21) Application No 9205973.2

(22) Date of filing 19.03.1992

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(51) INT CL^5
H04R 3/08 9/06 // H04R 1/02

(52) UK CL (Edition L)
H4J JCA JGC J30F J31H

(56) Documents cited
GB 2145606 A GB 2068678 A GB 1380929 A
WO 84/00460 A1 US 4928312 A US 4870690 A

(58) Field of search
UK CL (Edition K) H4J JAB JBA JCA JCB JGB JGC JGX
INT CL^5 H04R 1/02 1/20 1/22 1/28 3/00 3/04 3/08 9/00 9/02 9/06
Online databases: WPI, CLAIMS, INSPEC

(54) Flat monopole loudspeaker

(57) A flat loudspeaker with built in baffle has non-linear responses with respect to the internal air pressure and magnetic field in the transducer. The non-linear responses are accounted for by digital electronic compensation, Fig. 5, and power amplification is included in the loudspeaker (see Fig. 6). This permits the loudspeaker to be much thinner than would otherwise be possible. The drive forces are applied over substantially the whole of a membrane, to avoid low and middle frequency modal distortion taking place in the sound-emitting surface. The loudspeaker is suitable for wall mounting with minimum intrusion into the room.

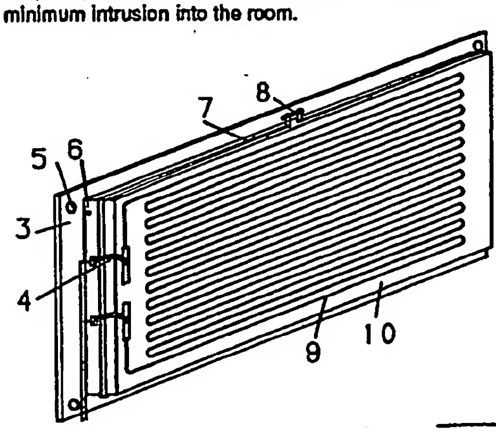

Fig 2

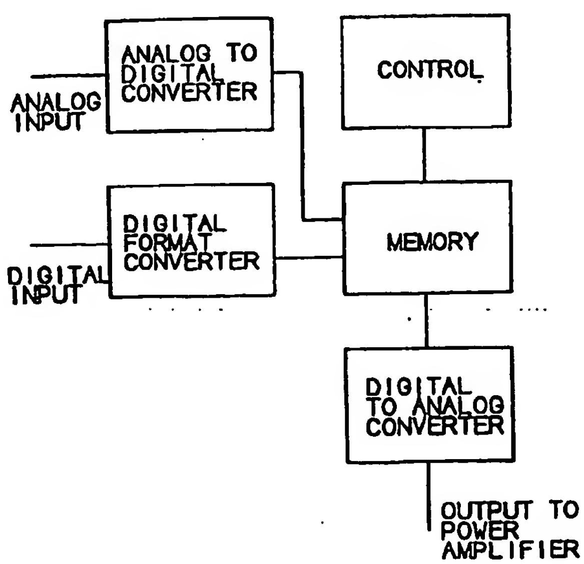

Fig 5

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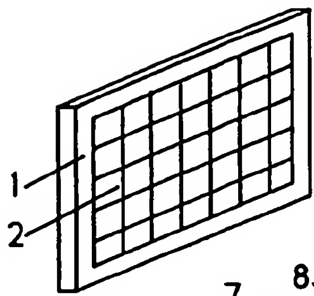

Fig 1

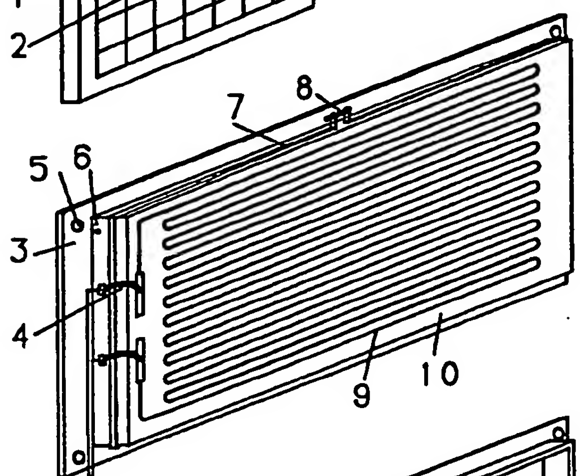

Fig 2

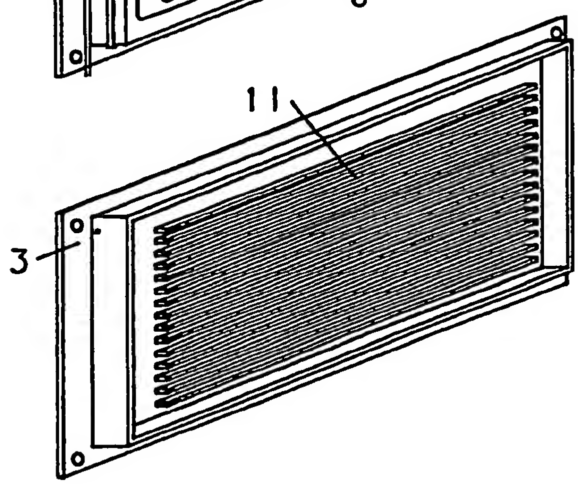

Fig 3

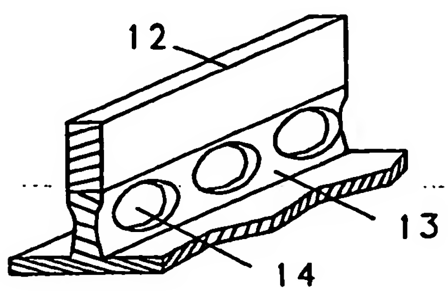

Fig 4

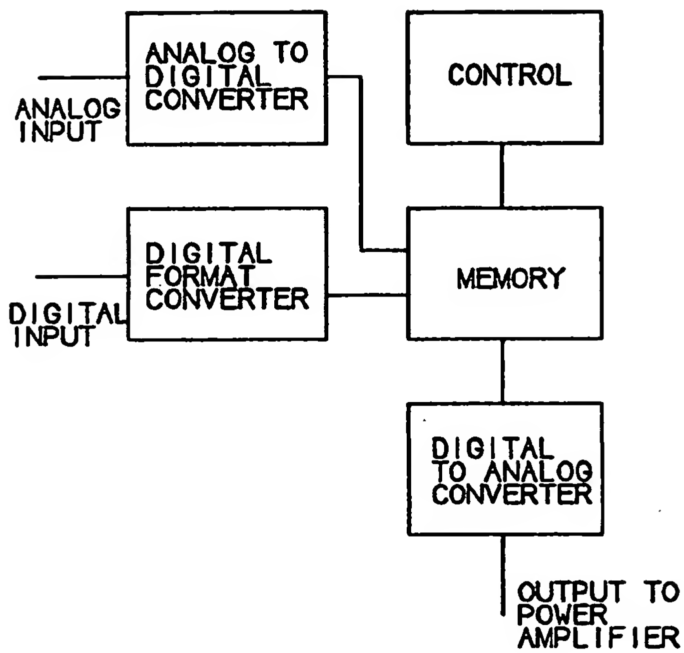
ANALOG TO DIGITAL CONVERTER
ANALOG INPUT
CONTROL
DIGITAL FORMAT CONVERTER
DIGITAL INPUT
MEMORY
DIGITAL TO ANALOG CONVERTER
OUTPUT TO POWER AMPLIFIER

Fig 5

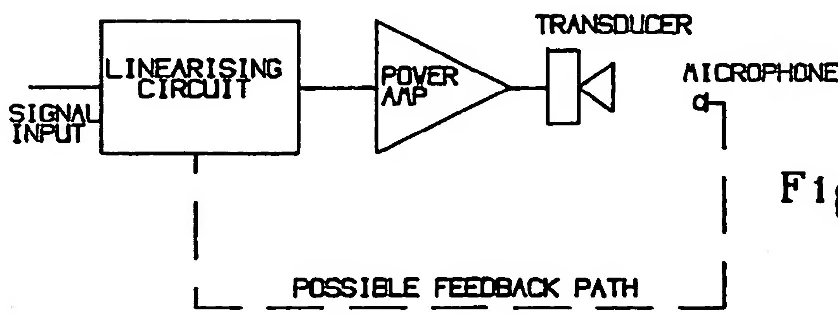
LINEARISING CIRCUIT
SIGNAL INPUT
POWER AMP
TRANSDUCER
MICROPHONE
POSSIBLE FEEDBACK PATH

Fig 6

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FLAT MONOPOLE LOUDSPEAKER

This invention relates to the design of a flat, thin loudspeaker with very shallow baffle.

All existing loudspeaker designs require either a large cavity in which to work, such as the monopolar 'infinite baffle' type, or have to be mounted well clear of walls etc. The latter category, often electrostatic types, suffer from adverse interference patterns from the front and rear surfaces of the radiating element, seriously reducing radiative efficiency at low frequencies, and causing a far from flat frequency response. These are dipole sources. Modifications to these basic types, such as the 'ported baffle', suffer from trade-offs introduced by the very increase in efficiency being sought. Any ported speaker radiates via its port a sound which causes spatial diffraction patterns, and amplitude modulation versus frequency. Current loudspeakers cannot be both thin and wall mounted without serious acoustic problems.

Furthur, all the traditional moving coil loudspeakers make an implicit assumption that the magnetic field that the coil moves in is of constant strength; actual deviation from this causes distortion of the acoustic wave form. Moving coil speakers are also at a disadvantage with respect to drivers (such as the electrostatic) where essentially the whole radiating surface is driven, because the moving surface is not infinitely stiff. This starts to become important in the mid-frequency range, where modal break-up of the surface occurs, with its consequent distortion of the wave field.

It is the object of this invention to provide a novel form of loudspeaker which is not subject to the deficiences of current loudspeaker design. It is an inherent facet of the design that linearity of transducer response is neither assumed nor approximated to. With that assumption removed, then the inherent non-linearity caused by permitting a significant pressure deviation within the speaker cavity can also be handled. This means that the speaker can be very thin.

The loudspeaker comprises an electronic re-linearising device, a power amplifier with a fixed gain, and a transducer. The three elements should be considered as a single device, as the acoustic performance is a function of the combination, and cannot be isolated to any of the component parts.

A specific embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which :-

Figure 1 shows in perspective, the external appearance of the loudspeaker's transducer;

Figure 2 shows the transducer with grille and surround removed;

Figure 3 as Figure 2 with the membrane and associated components removed;

Figure 4 shows a cross-section in perspective of one of the magnet ribs;

Figure 5 is a block diagram of the electronic re-linearising device;

Figure 6 is a block diagram of the loudspeaker system.

The transducer (Fig. 1), while covering a range of sizes, would typically have a surface area of about a square metre, and a depth of a few centimetres. With its surround and acoustically transparent grille removed (Fig. 2), the backplate 3 and membrane 10 can be seen. The radiating element is this membrane, which is a thin sheet of an electrically insulating material, on which is printed or embedded a conducting strip 9. The layout of this strip is a function of the transducer embodiment chosen; in this case a set of parallel conductors linked at the ends. This conductor is connected electrically to feed wires from the power amplifier via flexible cables 4. With the membrane mounted and tensioned, in this embodiment using a flexible strip 7 and tensioning bolt 8, the cavity is airtight, except for a tiny hole 6, which permits slow equalisation to external air pressure. The mass and stiffness of the backplane is high compared with the membrane, with the result that the speaker effectively becomes a monopole source.

The drive force on the membrane is applied over a substantial portion of the membrane surface, thus avoiding modal break-up and consequent distortion of the emitted sound field.

In this embodiment, the backplate (Fig. 3) is a ferromagnetic plate 3, with holes for wall mounting 5. It has walls which form a part of the cavity's walls. Inside these run a number of parallel magnetic strips 11. These strips, of which one is shown in section in Figure 4, alternately have magnetic North and South poles on their top sides 12. The magnetic material or electromagnet 12 is mounted on a rib 13, with holes 14 bored to acoustically couple the spaces between the ribs.

The membrane is acoustically close (over a good portion of the audible spectrum) to the backplane, and as the membrane is driven over most of its surface (each conducting strip being in the acoustic near-field of the next) then both low to middle frequency membrane resonances and volume resonances are avoided. With this thin layout, a significant pressure difference can occur between the cavity and exterior. By itself, this makes the displacement to drive-current characteristic quite non-linear, but monotonic. The magnetic field in which the membrane's conductors move is likewise non-linear; the field weakening as the membrane moves away from the magnetic ribs. To account for these factors, the incoming signal to be reproduced , whether analog or digital (Fig 5.) is fed into the electronic re-linearising device, which re-scales the incoming signal to give a displacement which is proportional to the input signal.

The re-linearising electronics comprises an input section, a memory and control section, and an output section. The input section comprises an analog to digital converter (ADC) to handle analog signals, a digital format converter to handle digital signals, together with filtering and gain control. The memory and control section may operate by several means; by using a look-up table, or carrying out algorithmic re-scaling to normalise the signal. Either of these may use parameters which may be modified by feed-back from a suitable sensor, such as a microphone or any displacement transducer. The output section comprises a digital to analog (DAC) converter with suitable filtering.

The power amplifier is any standard type, having fixed gain.

An additional feature of this embodiment is that at the extremes of input range, the conversion mentioned in the previous paragraph will deviate smoothly from the re-linearising curve, to exponentially approach a fixed maximum displacement. This protects the transducer from physical damage in the event of over-drive.

CLAIMS

1 A flat monopolar loudspeaker with built-in baffle, with the transducer operating in a non-linear fashion; the signal being re-linearised by an electronic device. The speaker thus takes into account the non-linear behaviour of the magnetic field and air pressure/displacement ratios, permitting operation with designs significantly differing from current loudspeakers, and being particularly thin and capable of wall mounting.

2 A flat monopolar loudspeaker as claimed in Claim 1 where the magnets providing the field are present on both sides of the membrane.

3 A flat monopolar loudspeaker as claimed in Claim 1 or Claim 2 where the magnetic ribs are polarised across their top surface.

4 A flat monopolar loudspeaker as claimed in any preceding claim, where the layout of magnets is in concentric circles, spirals or any shape topologically equivalent.

5 A flat monopolar loudspeaker as claimed in any preceeding claim where the non-linear effects are cancelled using feedback from the transducer to instruct the re-linearising device to update its conversion algorithms or values.

6 A flat monopolar loudspeaker as claimed in any preceeding claim where the non-linear effects are cancelled using adaptive control .

7 A flat monopolar loudspeaker as claimed in Claim 1 to Claim 4 above where re-linearisation is carried out making use of a look-up table or algorithm.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number
9205973.2

Relevant Technical fields

(i) UK Cl (Edition K) H4J (JAB JBA JCA JCB JGB JGC JGX)

(ii) Int CL (Edition 5) H04R 1/02 1/20 1/22 1/28 3/00 3/04 3/08 9/00 9/02 9/06

Search Examiner

P.J EASTERFIELD

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASE: WPI, CLAIMS, INSPEC

Date of Search

19 JUNE 1992

Documents considered relevant following a search in respect of claims 1 TO 7

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
A	GB 2145606 A (PIONEER)	1
A	GB 2068678 A (DBX)	1, 5, 6, 7
A	GB 1380929 A (MAGNEPAN)	1
A	WO 84/00460 A (CLARKE ET AL)	1, 2
A	US 4928312 A (HILL)	1
A	US 4870690 A (NEGISHI ET AL)	1, 5, 6, 7

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Category	Identity of document and relevant passages	Relevant to claim(s)

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